

# Airborne High Spectral Resolution Lidar and Research Scanning Polarimeter Measurements during RACORO



Chris Hostetler<sup>1</sup>, Richard Ferrare<sup>1</sup>, John Hair<sup>1</sup>, Anthony Cook<sup>1</sup>, David Harper<sup>1</sup>, Sharon Burton<sup>2</sup>, Mike Obland<sup>1</sup>, Ray Rogers<sup>1</sup>, Amy Jo Swanson<sup>2</sup>, Brian Cairns<sup>3</sup>, Mikhail Alexandrov<sup>3,5</sup>, Matteo Ottaviani<sup>3,4</sup>, Kirk Knobelspiesse<sup>5</sup>, Hafliði Jonsson<sup>6</sup>

<sup>1</sup> NASA Langley Research Center, Hampton, VA, USA <sup>2</sup> Science Systems and Applications, Inc., Hampton, VA, USA <sup>3</sup> NASA/Goddard Institute for Space Studies, New York, NY <sup>4</sup> NASA Postdoctoral Program <sup>5</sup> Columbia University, New York, NY <sup>6</sup> Naval Postgraduate School, Monterey, CA

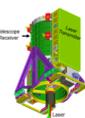
## Background

During June 2009 Routine AAF (Atmospheric Radiation Measurement, or ARM, Aerial Facility) CLOWD (Clouds with Low Optical Water Depths) Optical Radiative Observations (RACORO) field mission, the NASA Langley Research Center (LaRC) airborne High Spectral Resolution Lidar (HSRL) and the NASA Goddard Institute for Space Studies (GISS) Research Scanning Polarimeter (RSP) on the NASA B200 aircraft measured aerosol and cloud properties.

## Instruments aboard King Air B200

### High Spectral Resolution Lidar (HSRL)

- Independently measures aerosol and cloud extinction and backscatter profiles at 532 nm
- Profile Measurement capabilities
  - Extensive measurements
    - Backscatter at 532 and 1064 nm
    - Extinction at 532 nm
  - Intensive measurements
    - Color ratio (or Angstrom coeff.) for backscatter ( $\beta_{1064}/\beta_{532}$ )
    - Extinction-to-backscatter ratio at 532 nm
    - Depolarization at 532 and 1064 nm



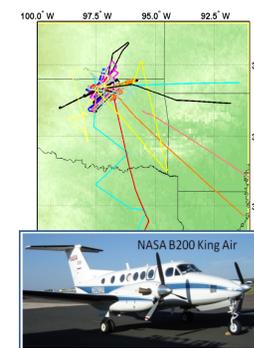
### Research Scanning Polarimeter (RSP)

- Precursor to APS on NASA Glory mission
- Measures total and linearly polarized reflectance in 9 spectral bands (412 nm – 2250 nm)
- Columnar Aerosol retrievals
  - Optical depth, Size distribution, Refractive index
- Cloud retrievals
  - Optical depth, Effective radius, variance of cloud droplet size distribution, Cloud top and base heights, and liquid water path and droplet number distribution

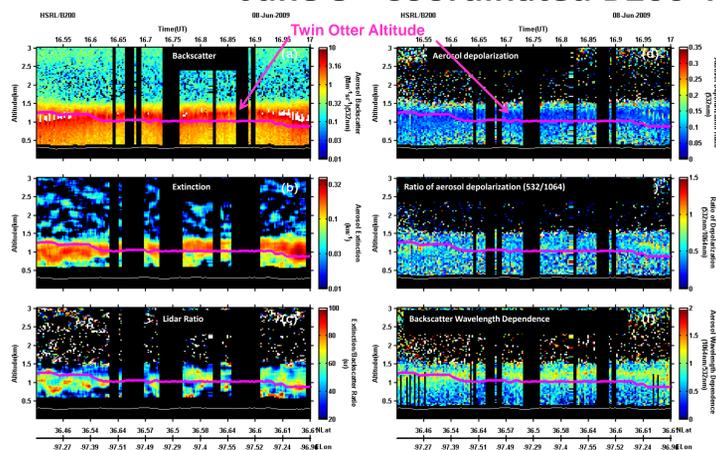


## RACORO Operations

- King Air B200 based in Ponca City, OK
- 19 science flights
- 15 flights coordinated with Twin Otter
- 4 flights included underpass of CALIPSO and A-Train
- 16 flights included overpass near or over DOE ARM SGP site

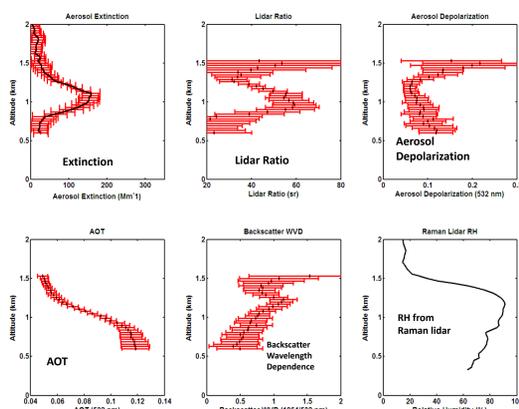


## June 8 - Coordinated B200-Twin Otter Flight

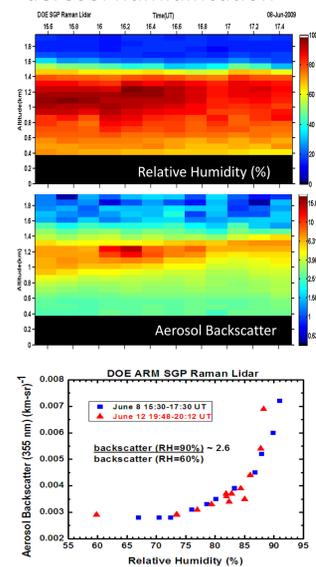


- HSRL measurements over 30 minute portion (16:30-17:00 UT)
- Vertical variability of aerosol parameters within PBL due to changes in RH

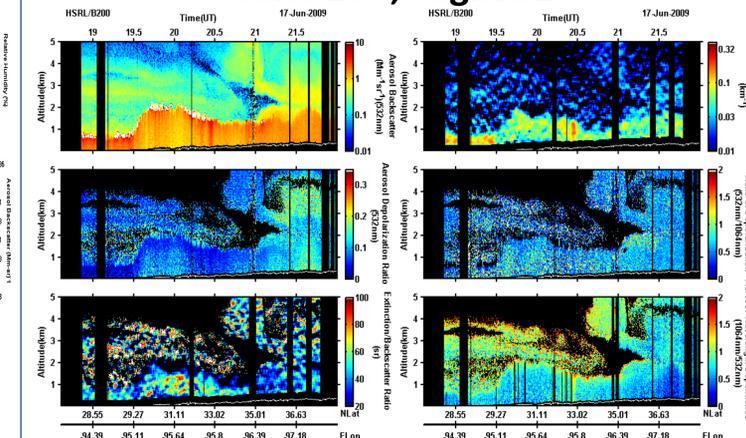
## Variation of aerosol parameters within PBL associated with humidification



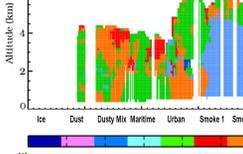
## Raman lidar measurements of aerosol humidification



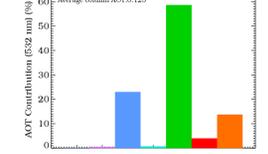
## Aerosol Type Analysis June 17<sup>th</sup>, Flight #2



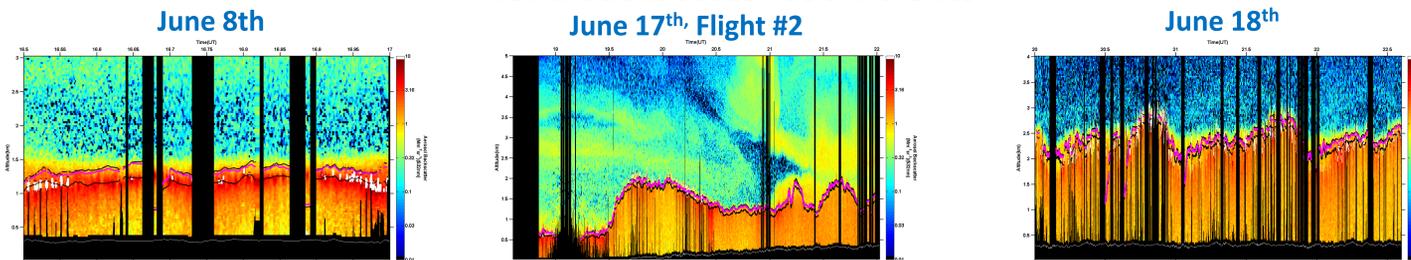
### Aerosol type vs. Altitude



### All June 2009 Flights



## Planetary Boundary Layer (PBL) heights and transition zones were obtained from HSRL backscatter coefficients

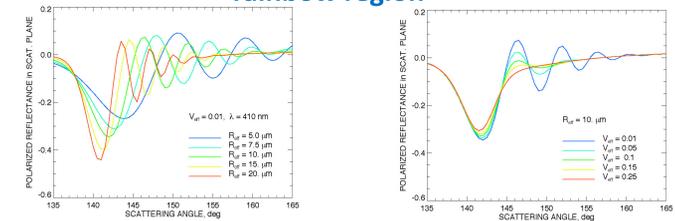


## RSP retrievals

Current methods for remote sensing of cloud droplet size in the solar spectral domain use:

- Reflectance in an absorbing and non-absorbing band (e.g. Nakajima and King, Platnick et al. using MODIS)
- Polarized reflectance observations** (e.g., Bréon et al. using POLDER)
- At present no instrument except RSP allows both methods to be used simultaneously.

## Cloud droplet size retrievals from polarized reflectance in rainbow region

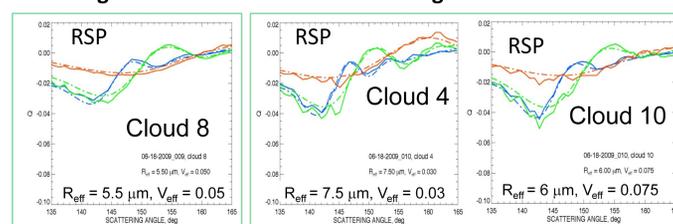


Sensitivity of polarized reflectance to effective radius (left) and variance (right) of cloud droplet size distribution.

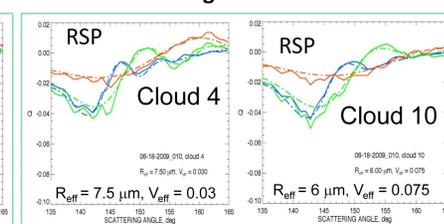
## June 18 - Twin Otter near cloud top:

Mean droplet size parameters from FSSP (Twin Otter) and RSP (King Air) are in general agreement:  $R_{eff} = 5-7 \mu\text{m}$ ,  $V_{eff} = 0.05-0.07$

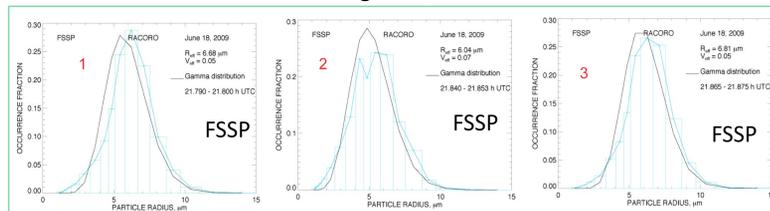
### Segment 9



### Segment 10



### Segment 16



## Summary

Airborne HSRL and RSP data were acquired during RACORO (June 2009) and used to:

- Investigate variations in aerosol properties near clouds and due to changes in relative humidity
- Evaluate RSP retrievals of cloud properties
  - Cloud drop size parameters derived from RSP are in good agreement with in situ FSSP measurements
- Provide vertical context for the Twin Otter in situ measurements
- Visualize the PBL height and distribution of aerosols within and above the PBL
- Characterize vertical and horizontal distribution of aerosol and aerosol optical properties, including mapping aerosol by type and partitioning optical depth by type

## Acknowledgements

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